subsidiary time server) for which the particular time server provides clock synchronization services. In each case, however, the time server acts as the reference source of time in determining offset using exchanges of time-stamped messages of the types described above. Thus, for example, a particular node (routinely, or in response to conditions detected at that node) may request that an associated time server initiate a synchronization sequence and supply the results to the particular node.

Numerous and varied particular applications of the present inventive principles, all within the spirit of the present description and scope of the attached claims, will prove useful to those skilled in the art.

What is claimed is:

1. In a network having a plurality of network nodes, each node having a clock, a method for determining information at a first network node for adjusting a clock at a selected second network node, the method comprising

determining an estimate of the offset of said clock at said second node relative to the clock at said first node, and

determining an estimate of bias of said estimate of said clock offset.

2. The method of claim 1 wherein said determining an estimate comprises exchanging a plurality of rounds of ordered time-stamped messages between said first node and said second node.

3. The method of claim 2 wherein at the *i*th of said rounds, $i = 1, \ldots, N$, where N is an integer, said messages comprise

from said first node, a first message to said second node comprising a time stamp T_i^0 indicating the current time at said first node when said first message is sent,

from said second node, a second message to said first node comprising a time stamp T_i^1 indicating the current time at said second node when said first message was received, and a time stamp T_i^2 indicating the time at said second node at which said second message is sent.

4. The method of claim 3 further comprising determining T_i^3, the time at which said second message is received at said first node.

5. The method of claim 4 further comprising determining at said first node for each i, $i = 1, 2, \ldots, n$

$$X_i \triangleq T_i^1 - T_i^0 \text{ and } Y_i \triangleq T_i^3 - T_i^2,$$

where

$$T_i^3 - T_i^2 = d^d - \theta + e_i^d$$

$$T_i^1 - T_i^0 = d^u + \theta + e_i^u \text{, and}$$

where θ is the offset of the clock at said second node from the clock at said first node, d^u is the fixed delay experienced by a message from said first station to said second station, d^d is the fixed delay experienced by a message from said second station to said first station, with d^u and d^d being equal or individually known, e_i^u is the variable delay at said ith round for a message from said first station to said second station, e_i^d is the variable delay at said ith round for a message from said second station to said first station.

6. The method of claim 5 further comprising determining an estimate, $\hat{\theta}_n$, of θ based on X_i and Y_i after n message exchanges between said first node and said second node.

7. The method of claim 6 wherein $\hat{\theta}_n = (U_n - V_n)/2$, where $U_n \triangleq \min_{i=1,\ldots,n}\{X_i\}$, and $V_n \triangleq \min_{i=1,\ldots,n}\{Y_i\}$.

8. The method of claim 7 wherein said estimate of bias of said estimate of clock offset, is determined based on separate determinations of $E[\min_{i=1,\ldots,n}\{X_i\}]$ and $E[\min_{i=1,\ldots,n}\{Y_i\}]$.

9. The method of claim 8 wherein said bias of said estimate of clock offset, is determined as $b_n \triangleq E[\hat{\theta}_n] - \theta$.

10. The method of claim 9 wherein $b_n = ((E[\min_{i=1,\ldots,n}\{X_i\}] - E[\min_{i=1,\ldots,n}\{Y_i\}])/2) - \theta$.

11. The method of claim 9 wherein said estimate of bias of said estimate of clock offset, is determined as

$$\hat{b}_n = \frac{1}{2}(\hat{\gamma}^X_n - \hat{\gamma}^Y_n) - \frac{1}{2}(\min\{X_i\} - \min\{Y_i\}),$$

where

$$\gamma^X_n = E[\min_{i=1,\ldots,n}\{X_i\}] \text{ and } \gamma^Y_n = E[\min_{i=1,\ldots,n}\{Y_i\}].$$

12. The method of claim 11 wherein a bias-corrected estimate for θ is given by

$$(\min\{X_i\} - \min\{Y_i\}) - \frac{1}{2}(\hat{\gamma}^X_n - \hat{\gamma}^y_n).$$

13. In a network having a plurality of network nodes, each node having a clock, a method for adjusting a clock at a selected second node to be more nearly in synchronism with a clock at a first node, the method comprising

determining an estimate of the offset of said clock at said second node relative to the clock at said first node,

determining an estimate of bias of said estimate of said clock offset, and

sending said estimate of said offset and said estimate of said bias to said second node to effect said adjustment of said clock at said second node.

14. The method of claim 13 wherein said determining an estimate comprises exchanging a plurality of rounds of ordered time-stamped messages between said first node and said second node.

15. The method of claim 13 wherein said first node is a time-server node providing estimates of offset of said clock and estimates of bias of said estimates of offset of said clock for each of a plurality of second nodes.

16. The method of claim 15 wherein at least some of said second nodes are time-server nodes serving respective pluralities of said second nodes.

17. The method of claim 15 wherein said exchanging of a plurality of rounds of messages is initiated for each of a plurality of second nodes by said first node.

18. The method of claim 15 wherein said exchanging of a plurality of rounds of messages for at least some second nodes is initiated by respective ones of said second nodes.

19. The method of claim 18 wherein said at least some second nodes initiate said messages by sending a message to said first node to send a first of said time-stamped messages.